COMSEARCH

Leadership and Diversity for Wireless

DIRECT BROADCAST SATELLITE (DBS) MEASUREMENT REPORT

Prepared For

DIVERSIFIED COMMUNICATIONS ENGINEERING
King Ranch, Texas

October 28, 1997

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SECTION 1

INTRODUCTION

1.1 General

This report provides the test data obtained during tests conducted at the King Ranch in Texas from October 7 to October 10, 1997. The purpose of the measurements was to attempt to determine the impact of a known interfering signal level on the reception of a video signal from a Direct Broadcast Service (DBS) satellite. This information was used to determine the Carrier-to-Interference (C/I) levels required by the satellite receiving system. Signal reception from the DIRECTV and ECHOSTAR satellites were monitored.

In addition to the C/I measurements, measurements were made to determine the changes in the DBS satellite receive antenna gain toward the interfering source when the satellite antenna was rotated through 360 degrees at a fixed elevation angle of 32 degrees, as well as the changes in the DBS satellite antenna gain in the direction of the interfering source as the antenna elevation was changed from 30 to 75 degrees

1.2 Background

Before preparing a measurement test plan and performing any measurements, we thoroughly reviewed both a DIRECTV report, "Terrestrial Interference in the DBS Downlink Band," submitted to the Federal Communications Commission on April 11, 1994, and an Engineering Report in Support of 12 GHz Experimental Applications prepared by D'Awder Communications, Inc.

1.3 Assumptions and Constraints

- The gain of the horn antenna used at the transmitter location was 10 dBi.
- The waveguide connecting the power amplifier and the transmitting antenna was 70 feet. The losses are estimated to be 2.1 dB based on the waveguide losses specified as 3 dB per 100 feet.
- The Channel Master receive antenna supplied with the system was either defective or for a different frequency band; therefore it was decided to use the DBS RCA system antenna and amplifier for all tests.
- Two DBS systems were provided for the tests. The RCA system operated satisfactorily, while the ECHOSTAR system had a faulty LNB and could not be used. The RCA system was used to receive signals from both DIRECTV and from ECHOSTAR.

- The interfering levels measured needed to be adjusted to account for the interfering source antenna being linearly polarized, while the DBS antenna is circularly polarized.

- The resolution bandwidth of the spectrum analyzer was set to 1 MHz. For an interfering signal with a bandwidth of 8 MHz, a correction factor of 9 dB is required to establish the actual interfering level. For the 24 MHz satellite signal the correction factor required is 13.8 dB to establish the satellite signal level. The correction factor in dB is based on 10*log(Signal Bandwidth / Resolution Bandwidth).

SECTION 2

CALIBRATION AND METHODOLOGY

2.1 General

In this section we will address the following:

- Transmitter Output Calibration
- Calibration of the Comsearch 12.5 GHz test system
- Experimental Microwave System Calibration
- DBS System Configuration and Verification
- Interference Testing
- Microwave System Coverage Test
- DBS Antenna Pattern Tests

2.2 Transmitter Output Calibration

The terrestrial transmitter block diagram is presented in Figure 2.2-1. A WR75 flange to "N" was mounted to the output flange of the transmitter. An HP 11692D directional coupler was connected directly to the flange adapter. An HP 436A power meter with a 8481A sensor, a 20 watt load, and a termination were attached to the appropriate outputs of the coupler (Figure 2.2-2). The transmitter was verified to have an output level at full power of 29 dBm.

The Seavy antenna was connected directly to the output flange of the transmitter with 70 feet of Andrew EW127 waveguide (Figure 2.2-3). The estimated losses for the 70 feet is 2 dB based on the waveguide specification of 3 dB loss per 100 feet.

Terrestrial Transmitter Block Diagram

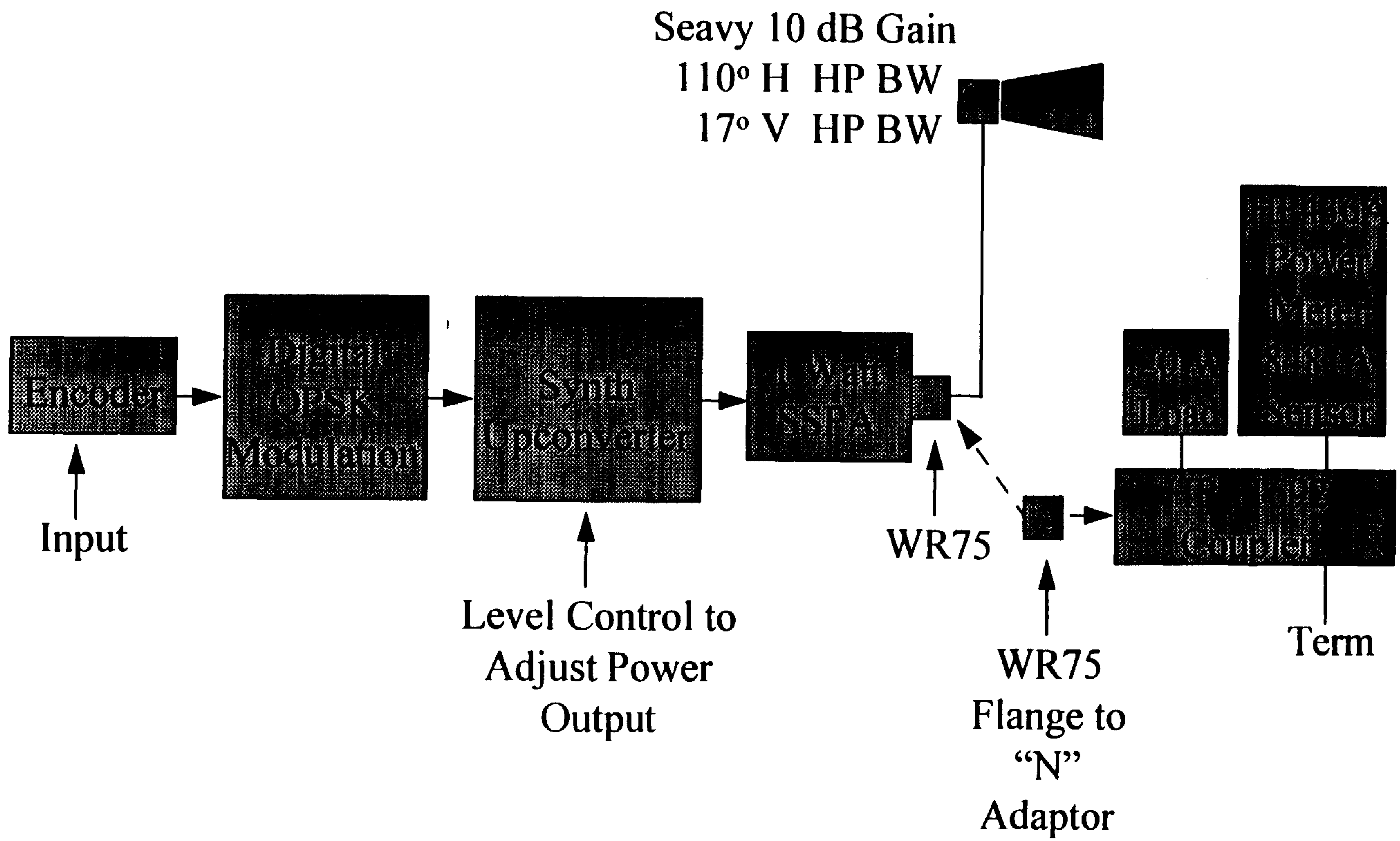


FIGURE 2.2-1

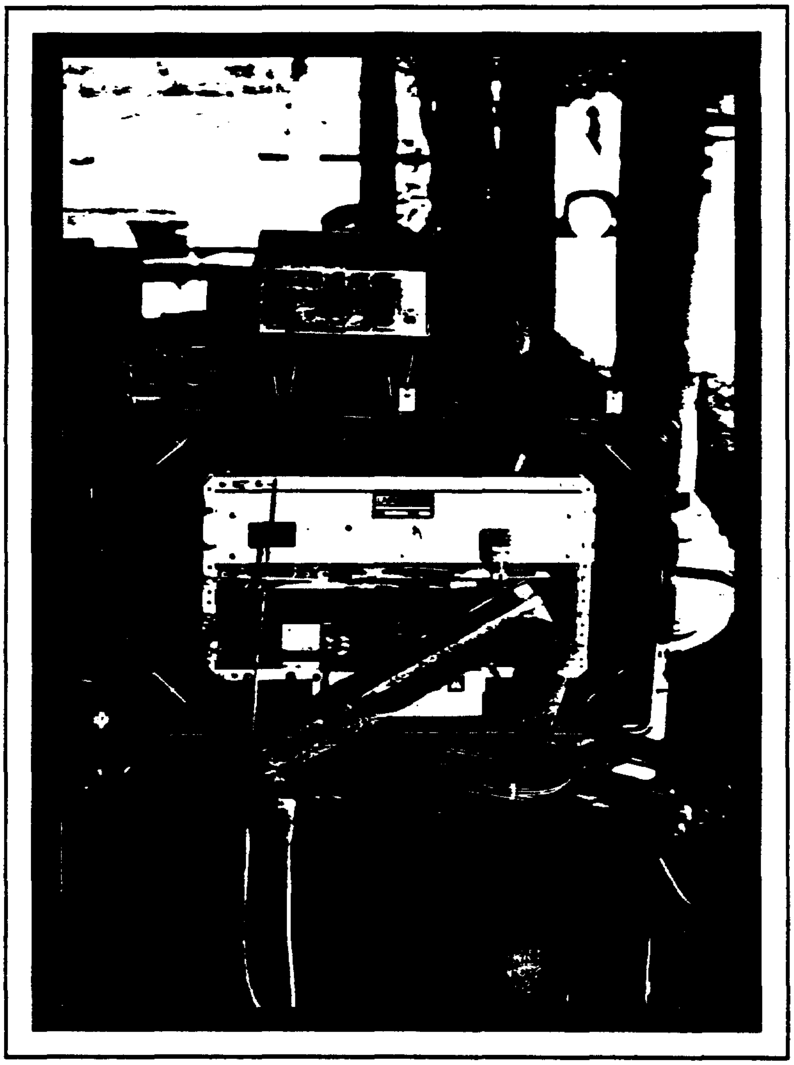


Figure 2.2-2 Transmitter Calibration Equipment

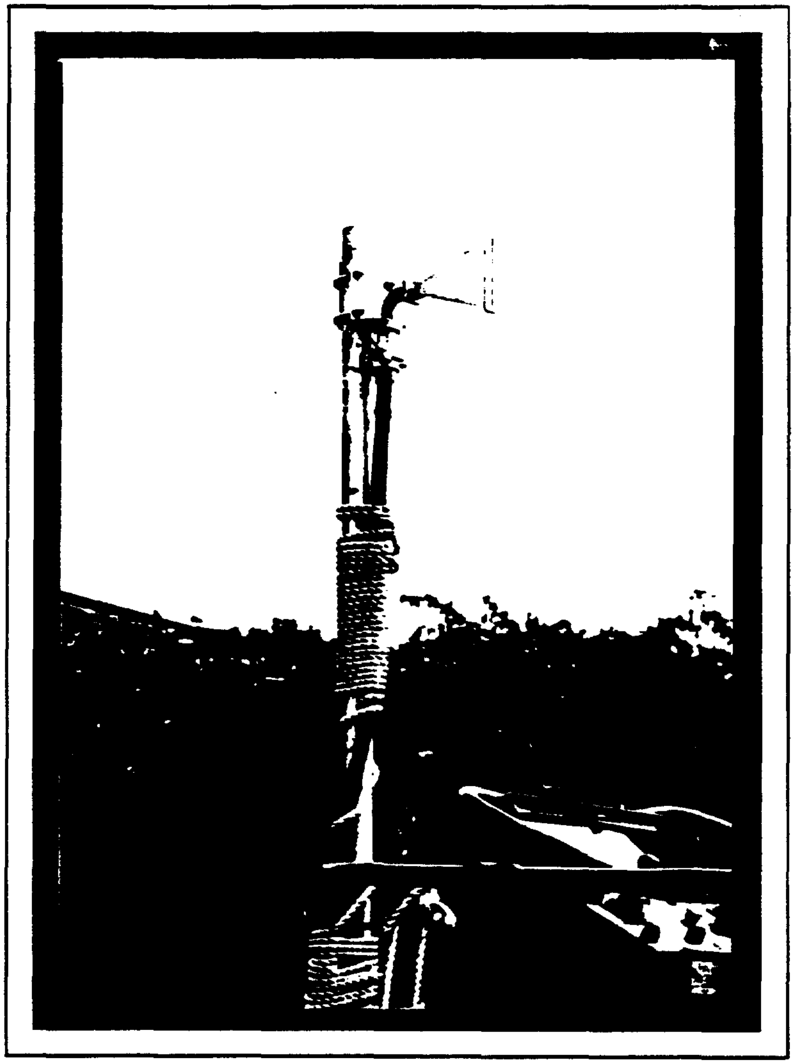


Figure 2.2-3 Transmit Antenna Mounted on Boom

2.3 Calibration of the Comsearch 12.5 GHz Test System

The Comsearch Test System Block Diagram (Figure 2.3-1) and System Photograph (Figure 2.3-2) comprise the following:

a. Ailtech 91892-1 reflector with 94614-1 horn
   Frequency range 12.0 - 18.0 GHz
   Gain at 12.5 GHz = 34 dB
   Beamwidth = 4 degrees

b. 25' Andrew FSJ4 1/2" cable
   or
   10' Andrew FSJ4 1/2" cable

   Note: System calibration was done with both cables (ref. calibration photos). The majority of tests utilized the 25' cable. The isotropic top reference in all 12 GHz photos will identify the cable utilized.

c. Amplica AXM 545304 low noise amplifier

d. Tektronix 494P spectrum analyzer w/ C5C scope camera

e. HP 8672A synthesizer

f. HP 436A power meter w/ 8481A sensor

A calibrated output from the synthesizer (-50 dBm) was inserted into the system and registered on the analyzer at -4 dBm or -9 dBm depending on cable used in order to establish an isotropic top reference on the analyzer (Figures 2.3-3 and 2.3-4).

At all measurement locations this test system was used to establish an isotropic level (LOS) from the transmitter and to verify output level variations.

Comsearch Test Set Block Diagram

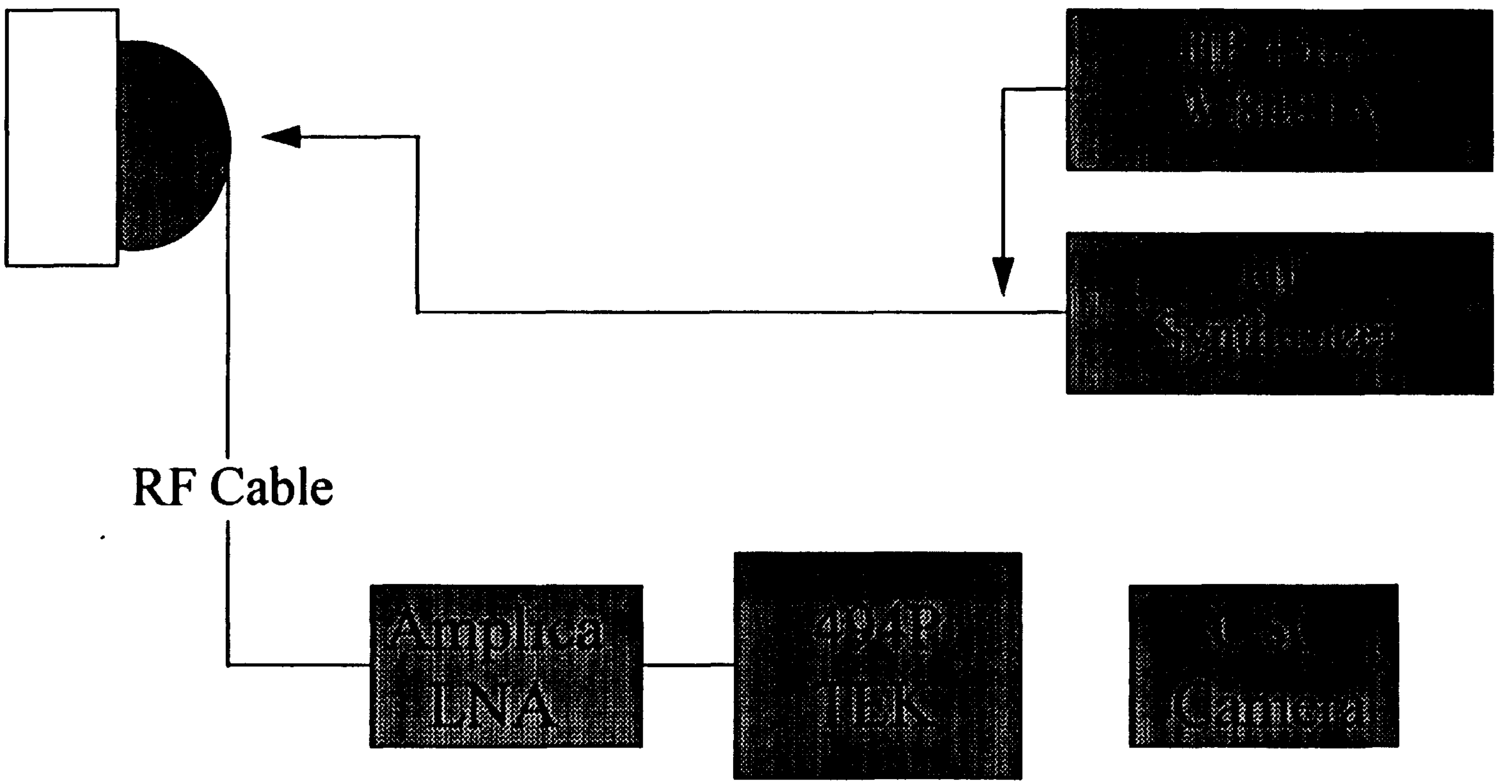


FIGURE 2.3-1

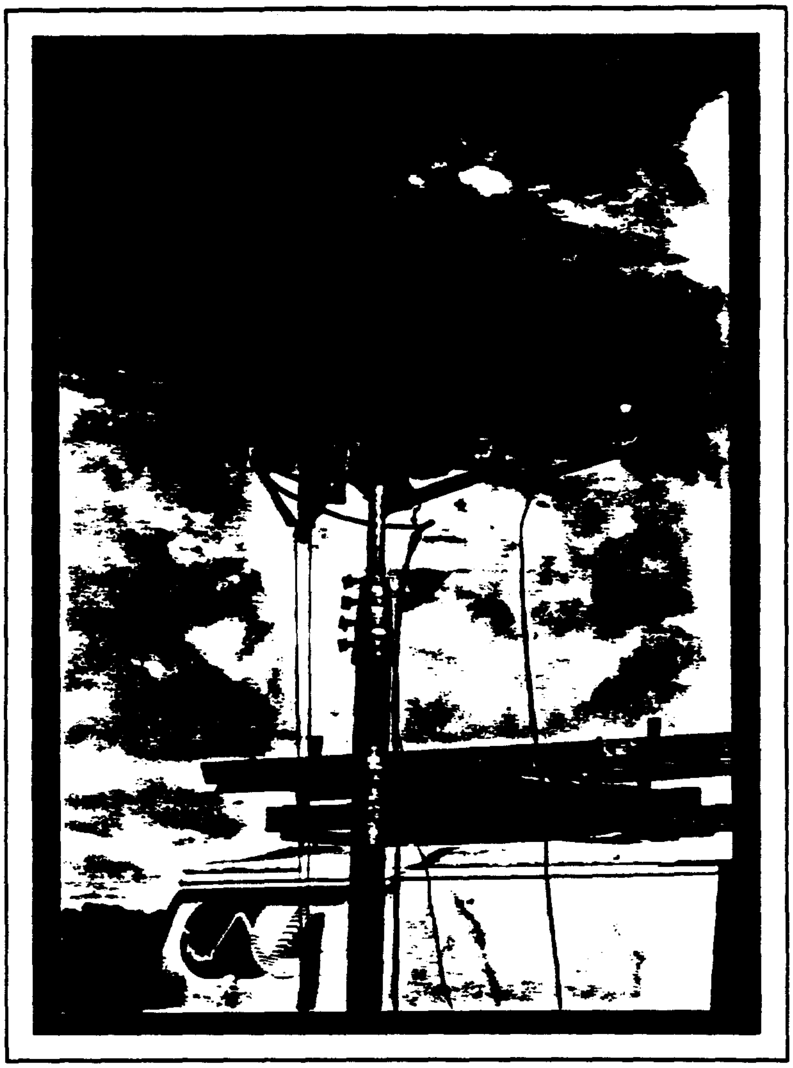


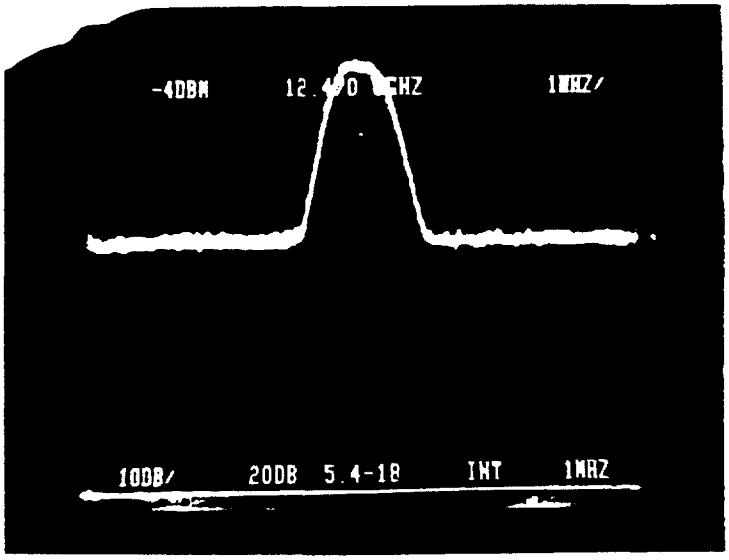
Figure 2.3-2 Comsearch Test Set/DBS Antenna Mount

King Ranch, Texas

Diversified Communications Engineering

Reference
Level
dBm$_I$

-84



Date: October 7, 1997
Calibration Photograph
Center Freq: 12470 MHz
Span/Div: 1 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 10 dB

-4 dBm, 12470 MHz signal indication on the spectrum photograph represents a -50 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

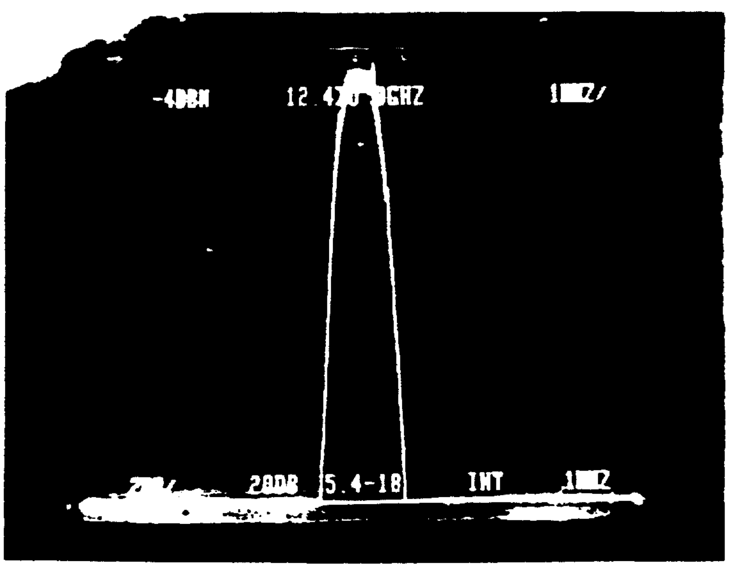
Top Reference Level is equal:
-50 dBm injected signal
-34 dB antenna gain

-84 dBm$_I$

(A)

Reference
Level
dBW$_I$

-84



Date: October 7, 1997
Calibration Photograph
Center Freq: 12470 MHz
Span/Div: 1 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 2 dB

-4 dBm, 12470 MHz signal indication on the spectrum photograph represents a -50 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

Top Reference Level is equal:
-50 dBm injected signal
-34 dB antenna gain

-84 dBm$_I$

(B)

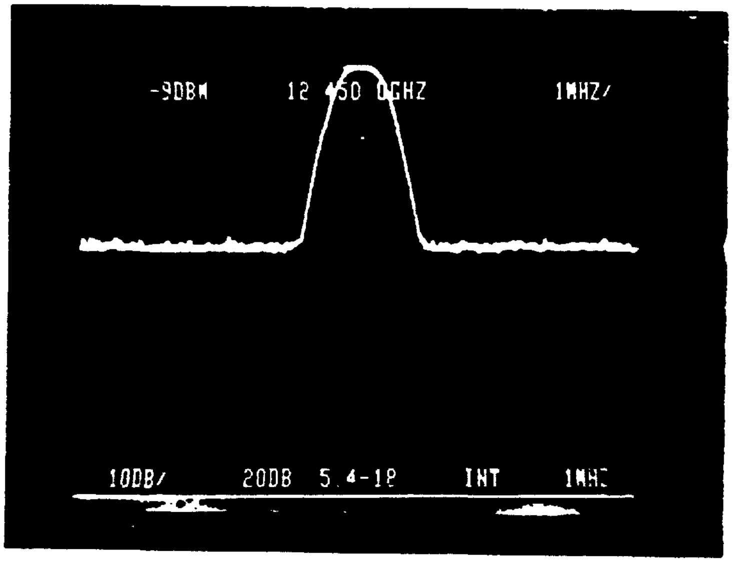
Figure 2.3-3 RF Calibration Photograph (Short Cable)

King Ranch, Texas

Diversified Communications Engineering

Reference
Level
dBm_I

-84



Date: October 7, 1997
Calibration Photograph
Center Freq: 12450 MHz
Span/Div: 1 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 10 dB

-9 dBm, 12450 MHz signal indication on the spectrum photograph represents a -50 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

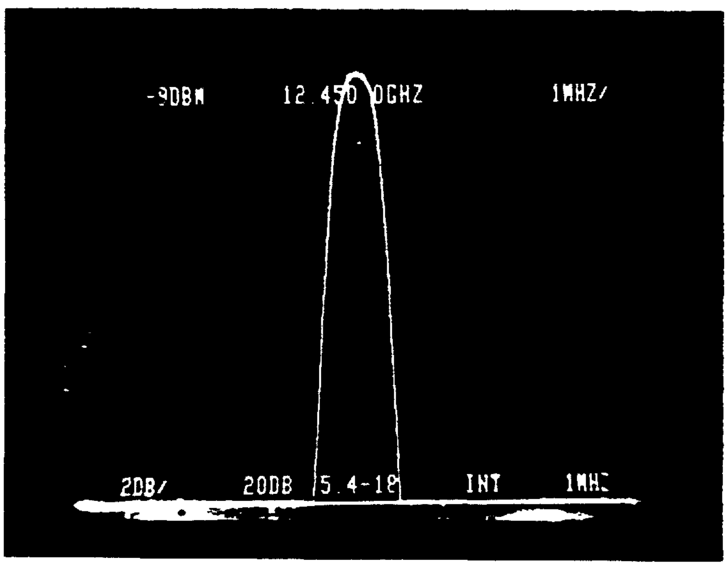
Top Reference Level is equal
-50 dBm injected signal
-34 dB antenna gain

-84 dBm_I

(A)

Reference
Level
dBW_I

-84



Date: October 7, 1997
Calibration Photograph
Center Freq: 12450 MHz
Span/Div: 1 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 2 dB

-9 dBm, 12450 MHz signal indication on the spectrum photograph represents a -50 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

Top Reference Level is equal
-50 dBm injected signal
-34 dB antenna gain

-84 dBm_I

(B)

Figure 2.3-4 RF Calibration Photograph (Long Cable)

2.4 Experimental Microwave System Calibration

After discovering that the Channel Master Receive Antenna supplied with the system was either defective or more likely the wrong antenna, it was decided to utilize the RCA DBS System antenna and amplifier (Figure 2.4-1). This antenna mounted on a stable telescopic mast with full azimuth and elevation rotors.

For this reason the output of the DBS ant./amp. was connected to the video rcvr./decoder and the 494P analyzer with a 2-way power divider. The transmitter isotropic level at each site as determined with the Comsearch test system was then directly referenced to the level as seen on the analyzer through the DBS System thereby establishing an L-band isotropic level from the transmitter.

It should be noted that the same power divider and cables were utilized at all times when the RCA DBS System was used either as a microwave receiver or a DBS receiver.

Terrestrial System Receive Block Diagram

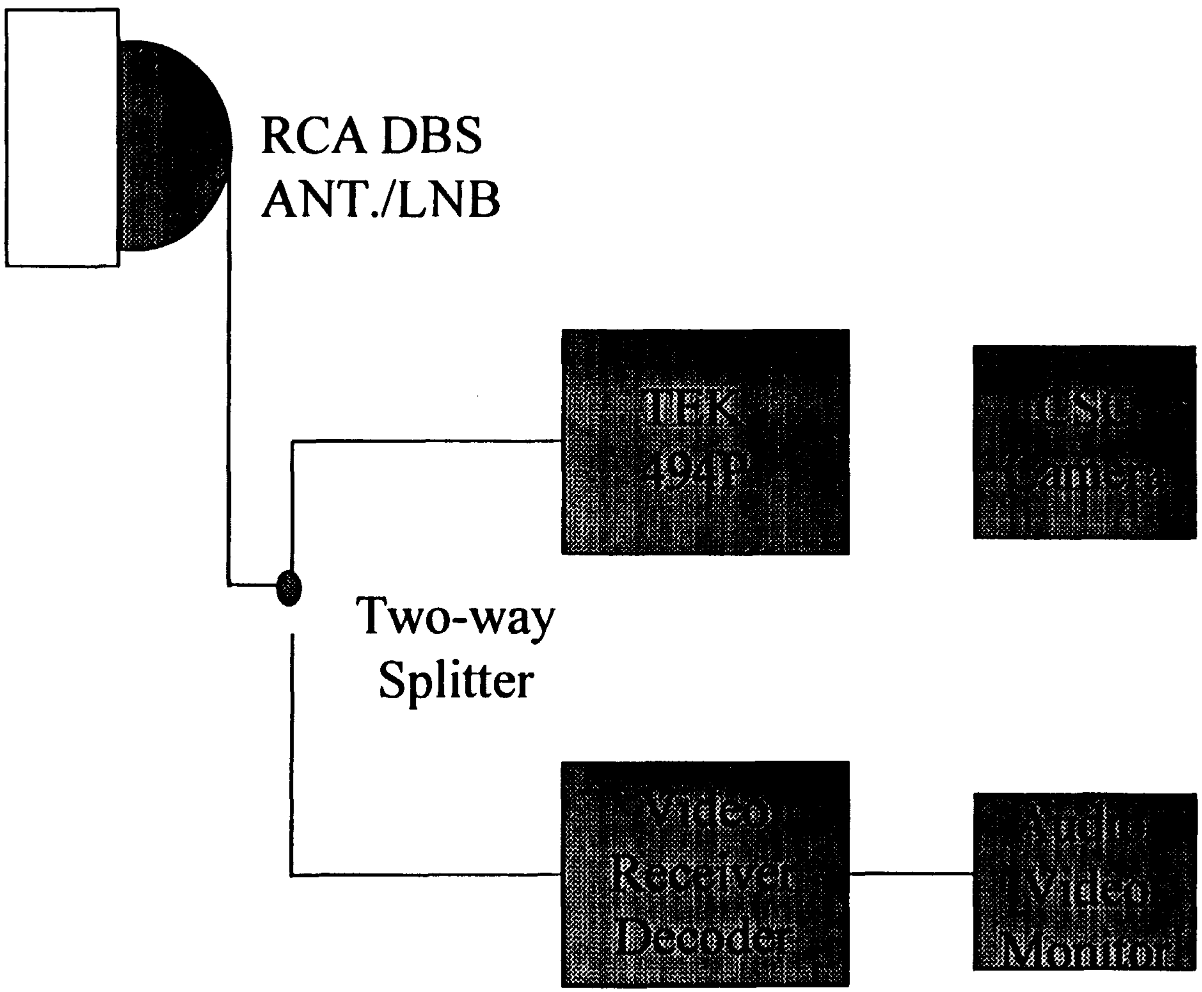


FIGURE 2.4-1

2.5 DBS Systems Configuration and Verification

Two complete DBS systems were to be used for these tests: an RCA DIRECTV System (Figure 2.5-1) and an ECHOSTAR System. Since the ECHOSTAR System was delivered with a faulty LNB, it was decided to use the RCA DBS antenna and LNB for all tests.

The output of the RCA System was connected to a 2-way power divider and connected to the 494P analyzer and either the DIRECTV or the ECHOSTAR receivers as appropriate.

Since the isotropic level of the microwave interference was determined with the Comsearch calibrated test system, an L-band isotropic reference was established at each location based on the tests as documented in Section 3. This was possible since the same divider and cables were used at all times.

DBS Receive Block Diagram

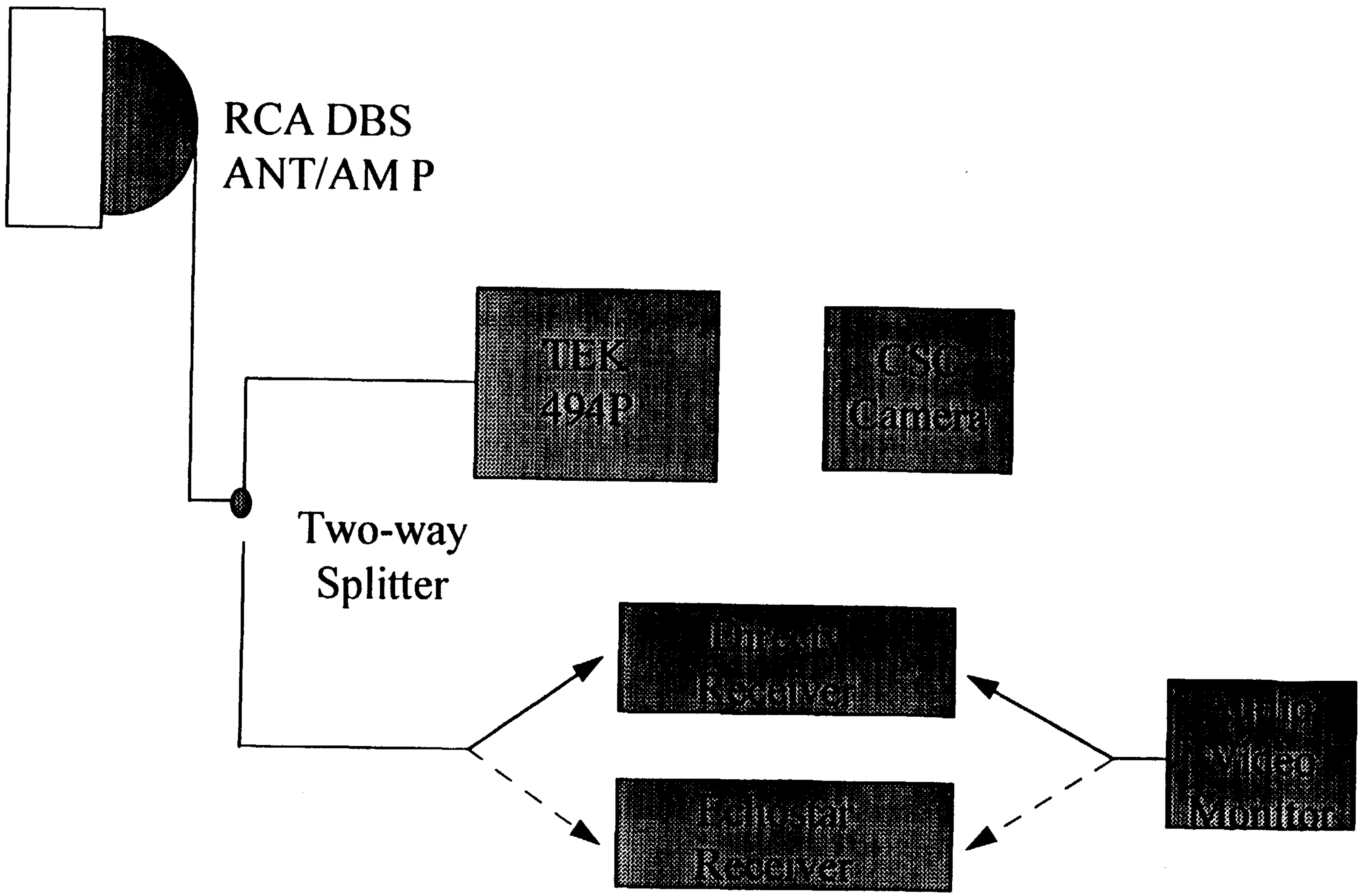


FIGURE 2.5-1

2.6 Interference Testing

The interference effects of the experimental transmitter into the DBS systems were tested at eleven (11) various locations around the transmitter (Figure 2.6-1). Table 2.6-1 presents a listing of the transmitter locations and receive sites.

The transmit antenna was elevated to 52' AGL with a boom lift and positioned on a center azimuth of 180 degrees true with horizontal polarity. This was not changed during the 5 day test period.

At ten of the test sites a line of sight condition between the transmitter and ALL receive test antennas was achieved at a receive centerline of 9' AGL. At one site the receive antennas had to be elevated to 20' AGL to establish a line of sight condition with the transmitter due to tree blockage at 9' AGL.

Once a line of sight condition was verified the Comsearch test set was used to establish an isotropic receive level from the transmitter at full power (29 dBm).

The DBS system was then positioned for DIRECTV and peaked using the display on the 494P analyzer. For DIRECTV tests the transmitter was tuned to 12470 MHz. This frequency is near the center of the transponder that carries Channel 242 (see note below). If interference was present the transmitter was lowered in power until no interference was detected and that level was recorded.

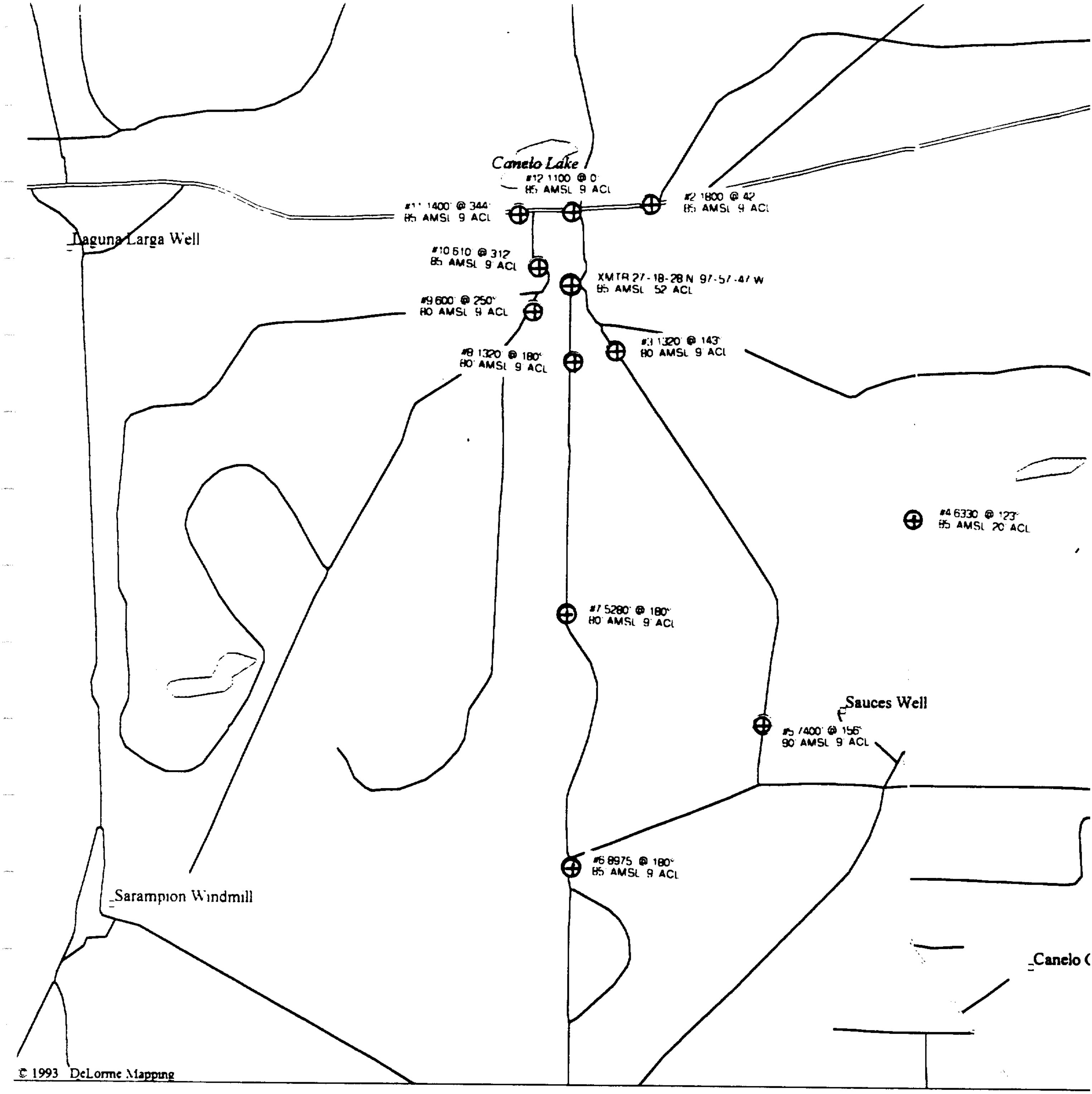
The DBS system was then positioned for ECHOSTAR. The transmitter was tuned to 12460 MHz. The same process as used for DIRECTV was then followed for Channel 220 on ECHOSTAR.

NOTE 1: Since DIRECTV and ECHOSTAR will not release channel loading information, the test frequencies for DIRECTV were derived from previous tests performed by Comsearch Senior Field Engineer, James Branin. The test frequency and channel effected for ECHOSTAR were determined in the field during testing.

12470 MHz is near mid-transponder for the DIRECTV transponder that carries Channel 242.

12460 MHz is near mid-transponder for the ECHOSTAR transponder that carries Channel 220.

It should also be noted that since the DBS signals are TDMA, an interfering signal in any portion of the transponder affects all channels on that transponder equally.



LEGEND

- Geo Feature
- Street, Road
- Major Street Road
- Open Water

Scale 1:25,000 (at center)

2000 Feet

500 Meters

Mag 14.00

Mon Oct 13 12:03:41 1997

FIGURE 2.6-1

Table 2.6-1

List of Sites - King Ranch, TX - DCE Project

1. TEMPORARY TRANSMITTER — 27-18-28 N 85'AMSL; 97-57-47 W 52'ACL

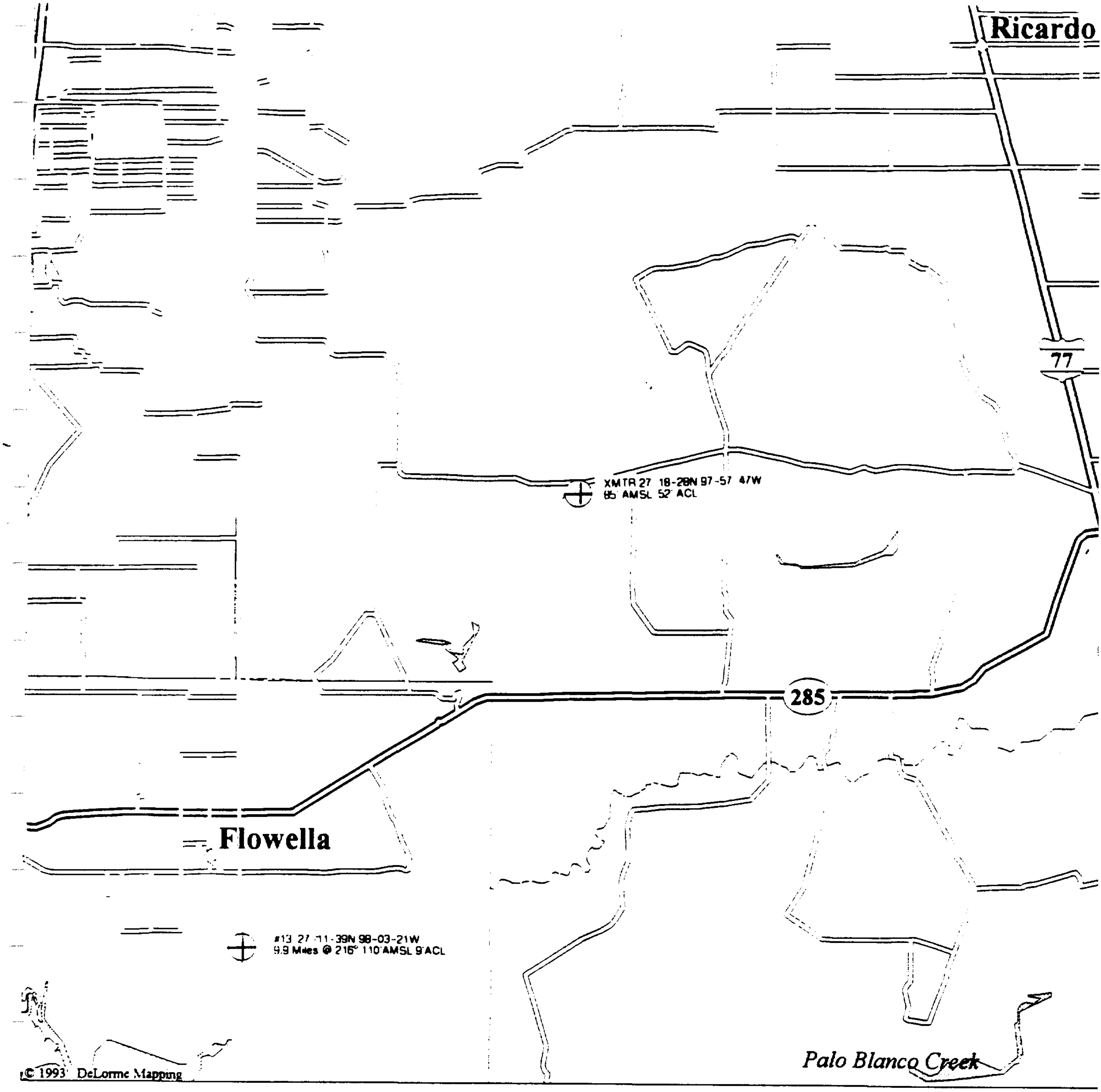
	Coordinates	Distance From XMTR	Azimuth From XMTR	LOS
2. TEST SITE #2	27-18-40 N 97-57-34 W AMSL = 85'	1800' TEST ANT. CL = 9'	42 DEGREES	YES
3. TEST SITE #3	27-18-18 N 97-57-39 W AMSL = 80'	1320' TEST ANT. CL = 9'	143 DEGREES	YES
4. TEST SITE #4	27-17-47 N 97-56-49 W AMSL = 85'	6330' TEST ANT. CL = 20'	123 DEGREES	YES
5. TEST SITE #5	27-17-22 N 97-57-14 W AMSL = 80'	7400' TEST ANT. CL = 9'	156 DEGREES	YES
6. TEST SITE #6	27-17-01 N 97-57-45 W AMSL = 85'	8975' TEST ANT. CL = 9'	180 DEGREES	YES
7. TEST SITE #7	27-17-37 N 97-57-47 W AMSL = 80'	5280' TEST ANT. CL = 9'	180 DEGREES	YES
8. TEST SITE #8	27-18-16 N 97-57-47 W AMSL = 80'	1320' TEST ANT. CL = 9'	180 DEGREES	YES
9. TEST SITE #9	27-18-24 N 97-57-53 W AMSL = 80'	600' TEST ANT. CL = 9'	250 DEGREES	YES
10. TEST SITE #10	27-18-31 N 97-57-52 W AMSL = 85'	610' TEST ANT. CL = 9'	312 DEGREES	YES

	Coordinates	Distance From XMTR	Azimuth From XMTR	LOS
11. TEST SITE #11	27-18-39 N 97-57-55 W AMSL = 85'	1400' TEST ANT. CL = 9'	344 DEGREES	YES
12. TEST SITE #12	27-18-39 N 97-57-47 W AMSL = 85'	1100' TEST ANT. CL = 9'	0 DEGREES	YES
13. TEST SITE #13	27-11-39 N 98-03-21 W AMSL = 110'	9.9 MILES TEST ANT. CL = 9'	216 DEGREES	UNK

2.7 Microwave System Coverage Test

Site 13 was picked for this test. The location is 9.9 miles on an azimuth of 216 degrees true from the transmitter site (Figure 2.7-1).

It is believed that with the transmitter at 85' AMSL plus 52' ACL (137' AMSL) and the receive antenna at 110' AMSL plus 9' ACL (119' AMSL), some tree blockage was present.



LEGEND

Population Center
State Route
Town, Small City
US Highway
County Boundary
Major Street Road
State Route
US Highway
Airfield

Open Water

Scale 1:150,000 (at center)

2 Miles

5 KM

Mag 11.00
Mon Oct 13 14:54:28 1997

FIGURE 2.7-1

2.8 DBS Antenna Pattern Tests

NOTE: FOR THESE TESTS ONLY, THE L-BAND ISOTROPIC LEVELS REFLECT THE 9 dB DIGITAL BANDWIDTH (8 MHz) CORRECTION FACTOR.

Pattern Test #1: This test was performed 5280' from the transmitter on a bearing of 180 degrees true from the transmitter. The RCA DBS antenna was mounted on the mast at 9' AGL (Ground Elev: 80' AMSL) and set for a 32 degree elevation angle. The transmitter was at 52' AGL (Ground Elev: 85' AMSL) with a pointing azimuth of 180 degrees true.

The isotropic level at the site was verified with the Comsearch test set.

The DBS antenna was rotated through 360 degrees in 15 degree increments and the isotropic levels from the transmitter were recorded.

Pattern Test #2: This test was performed 1320' from the transmitter on a bearing of 180 degrees true from the transmitter. The transmitter was at 52' AGL (Ground Elev: 85' AMSL) pointing on an azimuth of 180 degrees true. The DBS antenna was at 9' AGL (Ground Elev: 80' AMSL) pointing on an azimuth of 180 degrees true.

This site was chosen because it was well within the 17 degree HPBW of the transmit antenna and close enough to the transmitter to observe possible pattern variations when the elevation angle was changed.

The isotropic level was verified with the Comsearch test set.

The DBS antenna was varied in 5 degree increments from 30 - 70 degrees in elevation angle and the isotropic level from the transmitter was recorded.

SECTION 3

MEASUREMENT DATA

In this section the measurement data for the interference level tests and the antenna azimuth and elevation tests is presented.

3.1 Interference Measurement Tests

The interference measurement data is presented in Figures 3.1-1 through 3.1-22.